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FACILITIES FOR ELECTRONUCLEAR (MTA) PROGRAM

February 1953

AEC RESEARCH AND DEVELOPMENT REPORT

By

LIVERMORE RESEARCH LABORATORY

OF THE U. S. ATOMIC ENERGY COMMISSION

OPERATED BY

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LIVERMORE, CALIFORNIA

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LWS-24736

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INTRODUCTION

The objective of the Electronuclear (MTA) Program is the development of a positive ion accelerator-target assembly which can be operated for the production of fissionable material from fertile material at a competitive cost. MTA production objectives could include tritium, U233, radioactive warfare material, or weapons grade plutonium. In accordance with instructions from the Commission, substantially all effort is now being directed toward weapons grade plutonium production.

Progress to date has substantially proven the fundamental feasibility of linear proton or deuteron accelerators with sufficient beam current to produce fissionable material on a production scale and has established the probable production and operating characteristics of several target arrangements. Recent changes in conceptual design, together with preliminary cost studies, indicate that a revised linear accelerator approach to the problem should result in the development of a method of producing plutonium from depleted uranium at costs very substantially below those envisioned a year ago

The facilities described in the program proposal are required for the continued development of these new linear accelerator and target concepts with the objective of evaluating on a realistic industrial basis the feasibility and practicability of an MTA production plant.

The funds requested for MTA capital facilities for the California Research and Development Company total 4.0 million dollars in FY 1953 and 2.1 million dollars for FY 1954. Of the FY 1953 fund, 2.8 million dollars are already expended or committed.

The proposed use of these funds is summarized in this report along with a plot plan showing the location of existing and proposed facilities at the Livermore Research Laboratory. The various facilities have been grouped in accordance with the major phases of research and development work necessary to achieve the objective of the MTA program. The balance of this report is devoted to a more detailed description of these facilities.

Other capital facilities connected with the Power Breeder Reactor program assigned to California Research and Development Company by the Atomic Energy Commission are described in a separate report LWS-12720.

ELECTRONUCLEAR (MTA) PROGRAM

COST SUMMARY

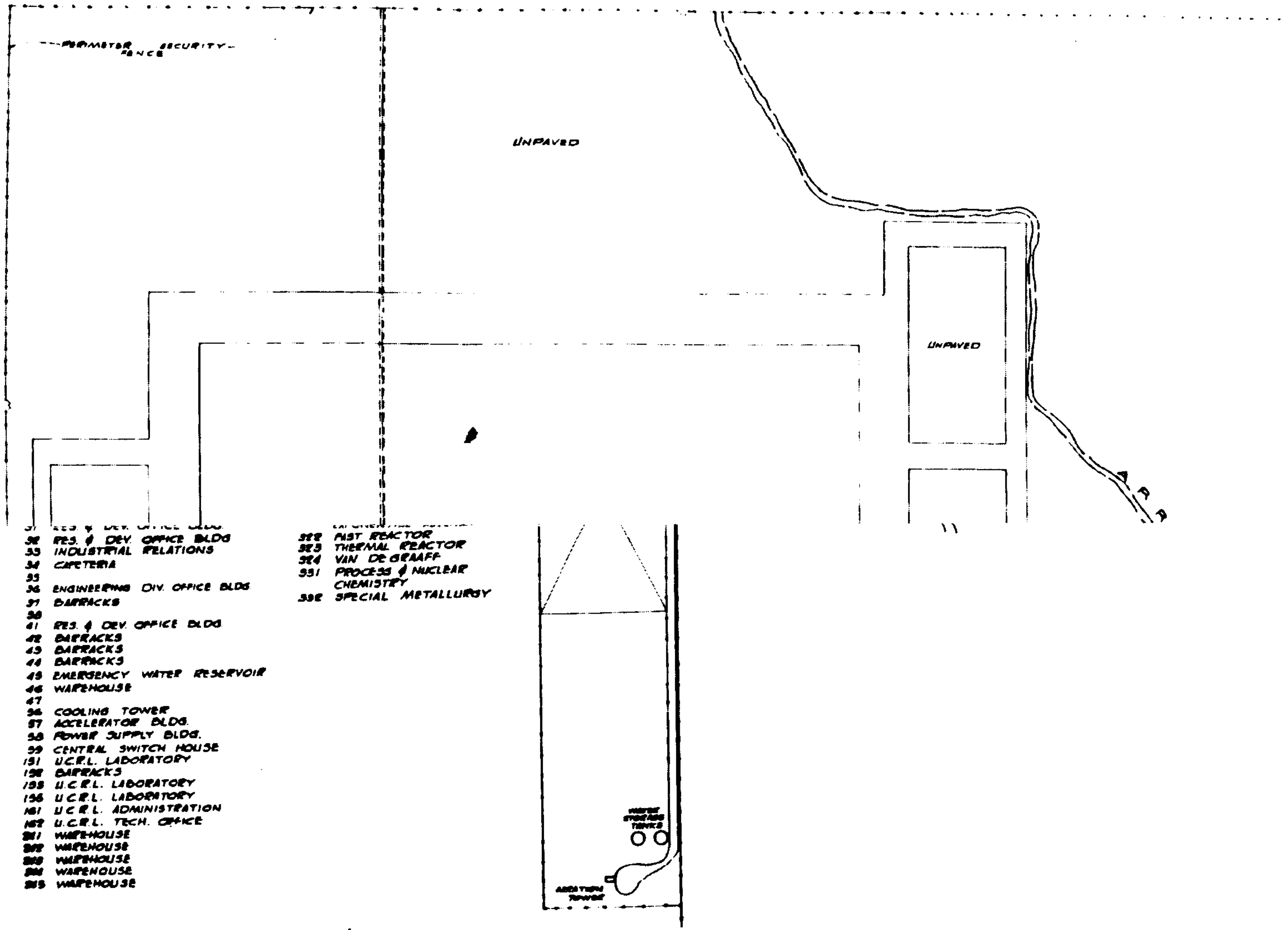
Item	Completed to 1/1/53	In Progress FY 1953	New Work FY 1953	New Work FY 1954
Mark I Accelerator and Auxiliaries	$13,308,943	$ 0	$ 0	$ 0
Modifications and Additions to Mark I Accelerator	552,036	259,461	401,965	702,319
High Power Oscillator Laboratory	1,848,809	62,469	0	25,000
Ion Source Development Laboratory	160,783	319	0	25,000
Miscellaneous Accelerator Research Facilities	156,067	24,525	38,300	19,000
Target Materials and Processing Laboratory	850,113	651,911	172,300	245,000
Experimental Neutron Physics Laboratory	54,217	227,135	10,700	81,509
Target Mechanical Development Facilities	2,808	0	66,000	119,000
Miscellaneous Building Alterations for Development Work	333,361	14,700	0	0

ELECTRONUCLEAR (MTA) PROGRAM (CON'T)

COST SUMMARY

Item	Completed to 1/1/53	In Progress FY 1953	New Work FY 1953	New Work FY 1954
General Livermore Site Facilities	1,820,543	145,310	451,381	1,000,000
A-12 Design and Weldon Spring Development	2,710,494	0	0	0
TOTAL	$21,798,174	$1,385,830	$1,140,646	$2,216,828

Locations and Budget Categories of Facilities are shown in Detail Cost Summaries



LIVERMORE RESEARCH LABORATORY

LIVERMORE, CALIFORNIA

MARK I ACCELERATOR & AUXILIARIES

A. Description

The Mark I Accelerator is a large steel tank approximately 60 feet in diameter and 80 feet long. This tank is evacuated to about a billionth of an atmosphere by a system of mercury diffusion pumps and mechanical vacuum pumps. The tank contains a copper liner which forms the actual resonant cavity and into which about 9,000 kilowatts of radio frequency power can be introduced at a frequency of 12.2 megacycles. This power is introduced by a system including an a-c generator, mercury arc rectifiers to produce d-c power, and radio frequency oscillators to convert the d-c power to radio frequency power. The radio-frequency power is introduced into the liner through transmission lines and magnetic field coupling loops. A proton or deuteron ion source, presently capable of over 2 amperes of d-c ion current, injects ions into one end of the vacuum tank centerline. The ions are alternately accelerated by the field in the tank and shielded when the field is reversed by coasting through copper-shell tubes (drift tubes) containing focusing magnets. The ions then emerge at the other end of the tank through a vacuum chamber into experimental target assemblies which are used to measure beam current, energy, and profile. The accelerator proper is entirely

enclosed in massive concrete shielding and is located in a large building which also houses auxiliary equipment and a control room, as depicted on the attached sketches.

In conjunction with the construction of the Mark I Accelerator, auxiliary facilities were added as needed. The Cold Laboratory was built to perform chemical analysis, electrolytic plating and chemical cleaning for research operation and maintenance. A Hot Laboratory was constructed and equipped to perform basic chemical research and chemical engineering studies in relation to radioactive materials produced in the accelerator target. Laundry and Decontamination facilities were built to launder clothing and equipment contaminated with radioactive or toxic chemical materials.

B. Utilization

The Mark I Accelerator was constructed at Livermore for the purpose of developing the technology and demonstrating the feasibility and operability of a comparatively large current linear accelerator. Results from previously available research accelerators had demonstrated the large yield of neutrons produced by high energy proton or deuteron bombardment of a uranium target, but it remained to be proven that an accelerator could be constructed which would provide steady proton or

deuteron beams of sufficient current and energy to produce fissionable material at attractive costs and in a practical manner. The construction and operation of Mark I to date, together with associated component development work, has established the feasibility of constructing such an accelerator with adequate current capacity.

In order to avoid excessive cost for this initial accelerator, it was constructed to provide low particle energy (15 mev protons or 30 mev deuterons); but the execution of the experimental program was such as to solve most of the problems involved with a higher energy machine of comparable current. In order to demonstrate the feasibility of currents of the order of a quarter of an ampere of positive ions, it was necessary to establish the feasibility of evacuating large vessels to approximately a billionth of an atmosphere, to feed large quantities of r-f power into a large resonant cavity, to focus the beam with magnets instead of grids, to hold high radio-frequency voltages across large gaps, to introduce collimated currents of ions into the accelerator, and to solve many lesser problems.

C. Need

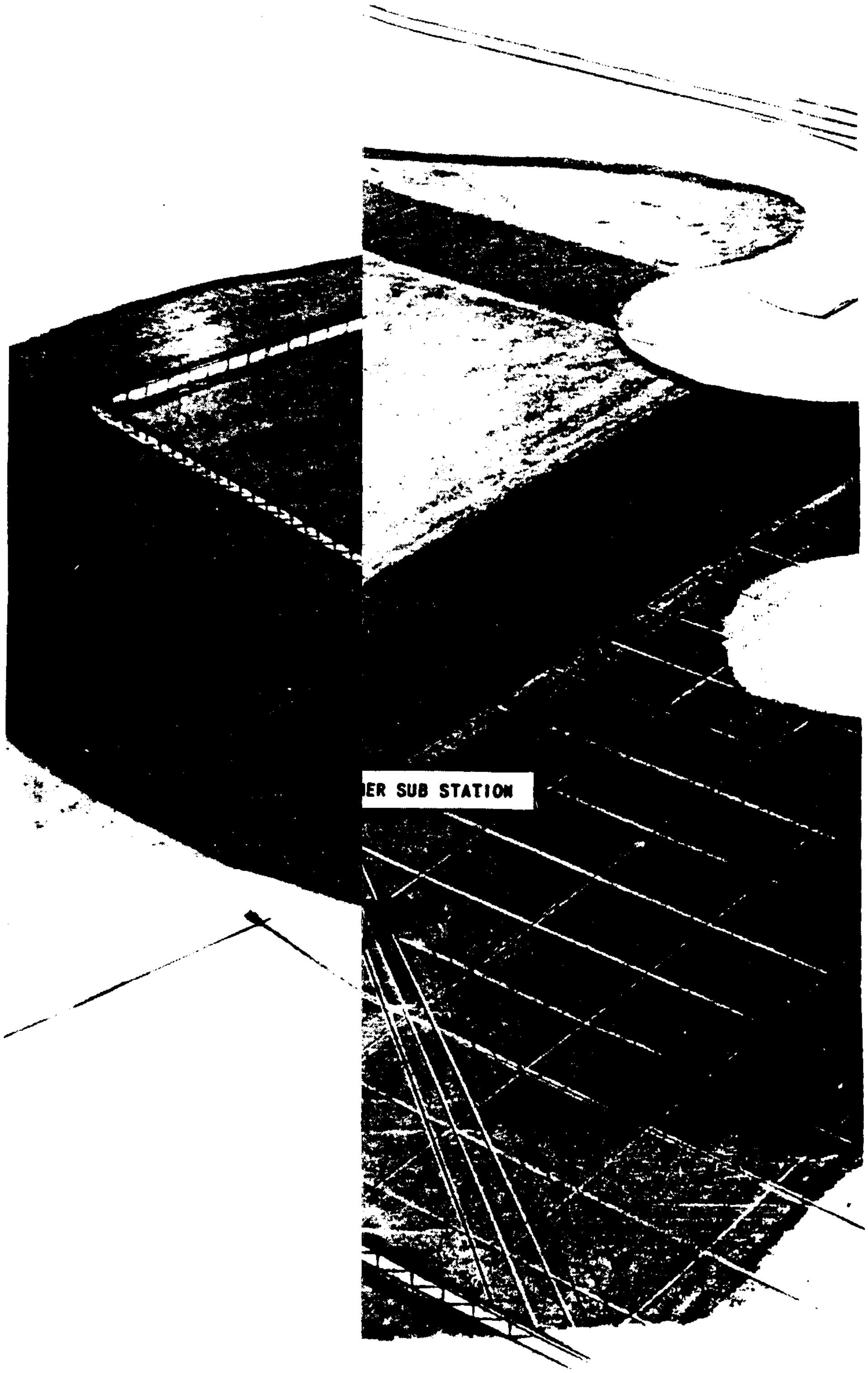
Mark I was constructed and has been operated as an experimental linear accelerator with the objective of establishing the production potentialities of the accelerator portion of an MTA electronuclear plant.

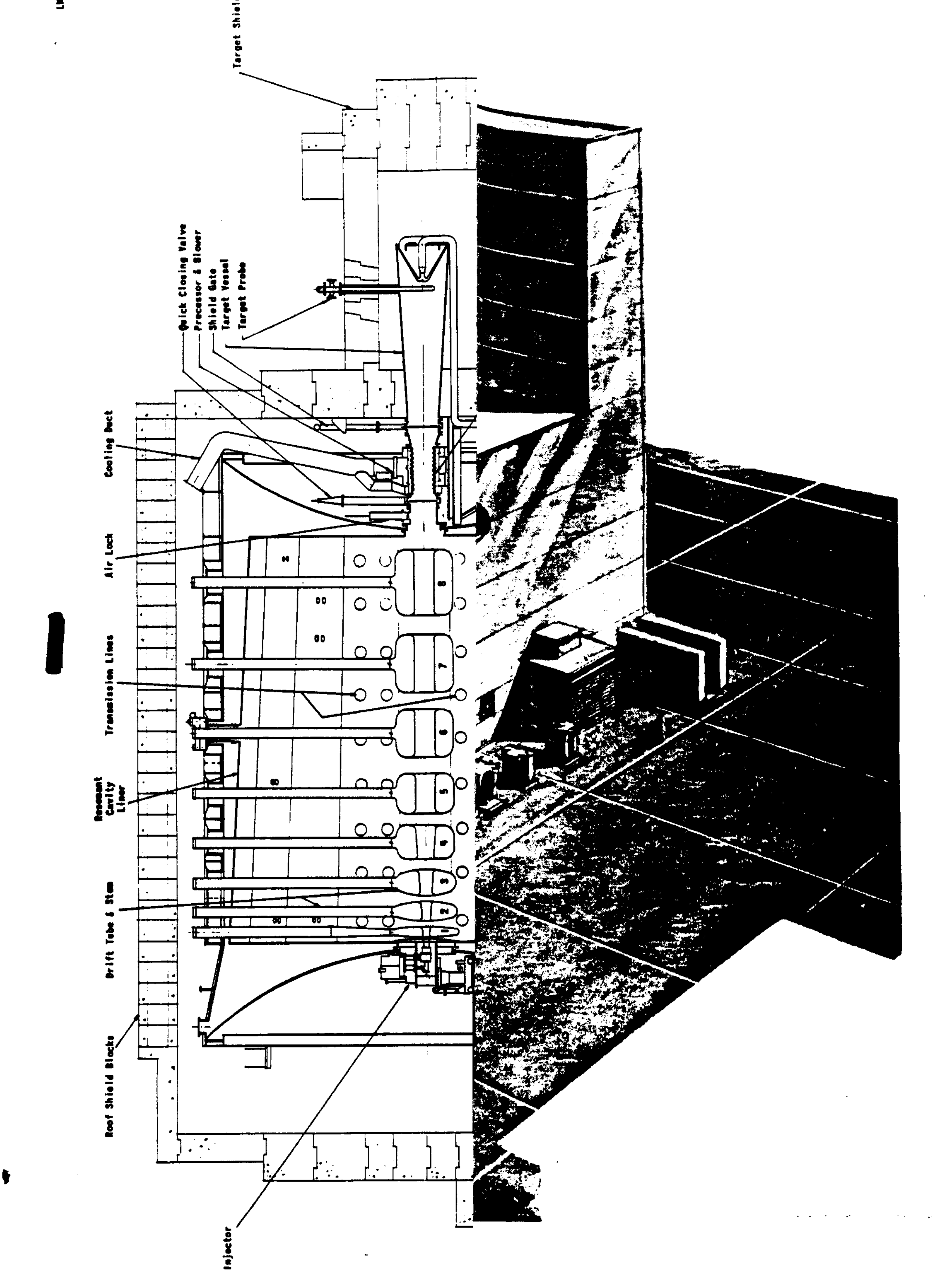
MARK I ACCELERATOR AND AUXILIARIES

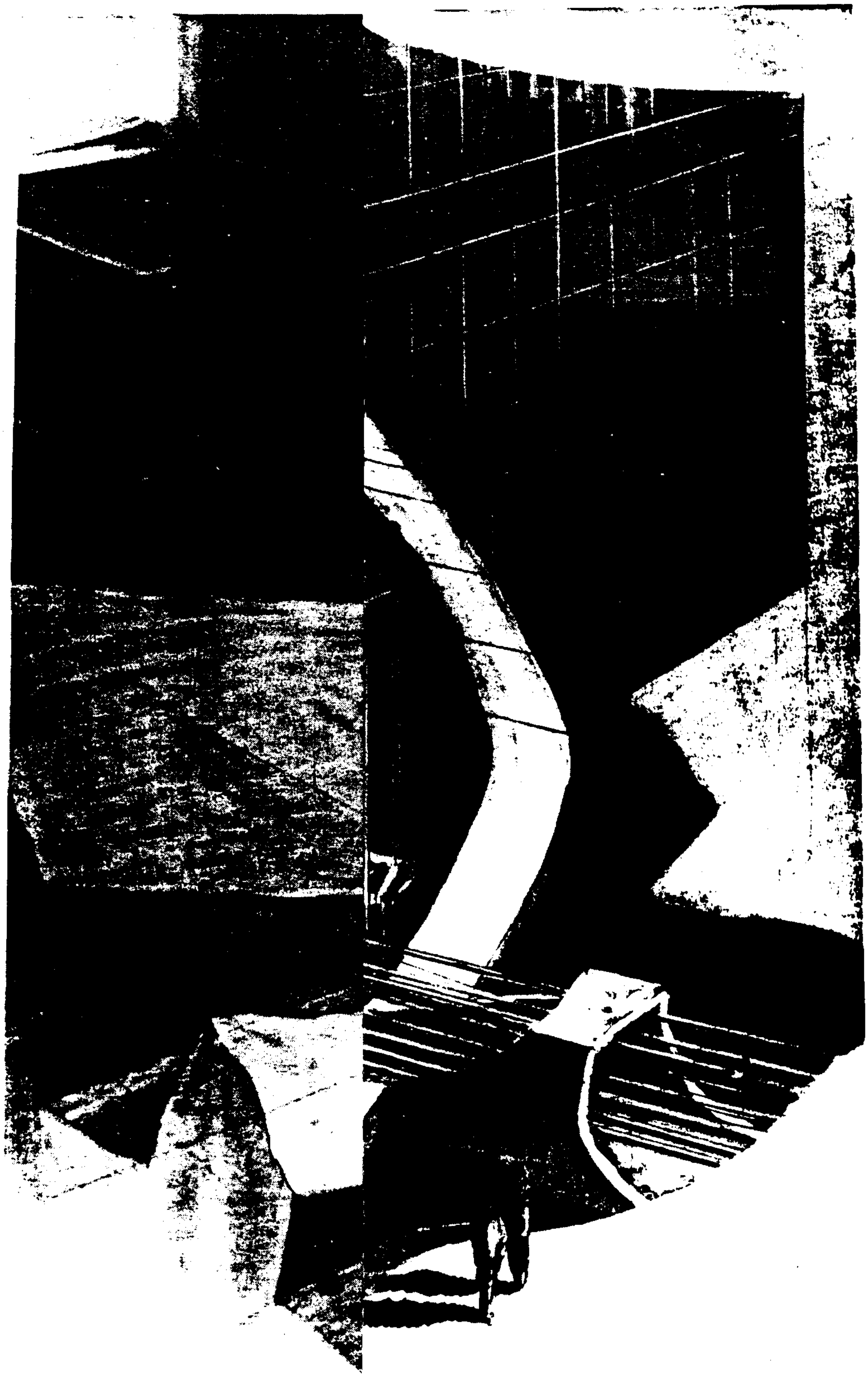
COST SUMMARY

Item and Location	Complete to 1/1/53	In Progress FY 1953	New Work FY 1953	New Work FY 1954
Acclerator (1) Building 57	$10,597,233	$ 0	$ 0	$ 0
Acclerator Building (1) Building 57	1,590,778	0	0	0
Main Power Supply (1) Building 58	90,119	0	0	0
Target (1) Building 57	690,025	0	0	0
Analytical Laboratory (2) Building 22	112,839	0	0	0
Low Level Radive Laboratory (2) Building 25	195,597	0	0	0
Decontamination Facility (2) Building 27	32,352	0	0	0
TOTAL	$13,308,943	$ 0	$ 0	$ 0

(1) Budget Category 2-271-0001-01
(2) Budget Category 2-271-0001-03


ER SUB STATION


LWS-24736
Target Shield Blocks
Quick Closing Valve
Processor & Blower
Shield Gate
Target Vessel
Target Probe
Cooling Duct
Air Lock
Transmission Lines
Resonant Cavity Liner
Drift Tube & Stem
Roof Shield Blocks
Injector



MARK I ACCELERATOR ALTERATIONS AND MODIFICATIONS

A. Description

This section covers a wide variety of alterations and modifications to the existing Mark I Accelerator and auxiliary facilities. Individual descriptions are given for each item in the following detailed tabulations.

B. Utilization

All of the proposed modifications are designed to contribute to the basic objectives of the Mark I research and development program; namely to provide technical information and operating experience for the design of an accelerator capable of producing deuteron beam currents and energies that can be utilized in a competitive electro-nuclear production plant.

C. Need

Knowledge and experience gained in the construction and operation of Mark I, together with the development at Brookhaven National Laboratory of a new type of beam focusing, has lead to modified linear accelerator concepts which should permit obtaining the same energies and currents with accelerators of greatly reduced cost and size, although with similar functional components.

Alterations and modifications to Mark I are needed to further improve

our understanding of such things as the phenomena of sparking in cavities across large gaps and with large energy storage, to improve and verify our ability to calculate the ion dynamics in accelerators, and to further develop RF power and ion source technology sufficiently to establish the feasibility of dependable industrial type operation of such a machine.

D. List of Modifications and Additions

Item	Description, Utilization and Need
1. Modifications and Additions to the Accelerator which are complete or in progress	General plant modifications and additions; modifications to drift tubes, periscopes, power supply 6, oscillators and additions to target. General improvement of accelerator operation.
2. Modifications and Additions to Power Supply and Control Equipment	
Emergency Power Switching	Emergency power switching. To switch between 110 KV and 12 KV feeder line. Required to protect equipment and personnel.

Grounding Switch for 40,000 KVA Transformer	Grounding switch for 40,000 KVA transformer. To ground transformer during repairs. Required for personnel safety.
Fast Switching for Checking Oscillators	Fast switching for checking oscillators. For checking metering for various oscillator circuits. Required to reduce time necessary for trouble shooting.
Modification to Light Dimming Equipment	Modification to light dimming equipment. For personnel warning inside shielding. Required for proper safety precautions not attained at present.
Power Supply 5 Overcurrent Protection	Install overcurrent metering and protection on Power Supply 5. For current measuring and protection. Required for safe operation of the equipment.
Condenser Conditioner	Provide condenser conditioner. For testing vacuum condensers. Required for effective oscillator operation.

3. Modifications and Additions to Oscillators	Oscillator Modifications and Power Supply modifications to drive Dl and D6 and to eliminate mechanical devices for cavity exitation. Required to decrease bakeout time by eliminating troublesome mechanical contactor and driving more power into accelerator during bakeout conditions.
4. Modifications and Additions to Target Area	
Secondary Air Lock	Air lock between bellows and Shield Gate. For analyzing beam characteristics. Required to permit introduction of test targets and special irradiation samples both before and after precessor.

Target Platform Modification	Modification of target platform and ladders which support airlock quick closing valve precessor and shield gate. For access to air locks and precessor. Required to eliminate high loads on vessel head, provide reasonable access to facilities at this location.
Test Target Handling Facilities	Handling facilities at air locks. For handling test targets. Required to permit remote handling of irradiated targets and samples.
Cooling Facilities at Transition Section	Installation of cooling facilities at transition section between bellows and shield gate. To maintain high vacuum. Required to protect vacuum gasket from over-heating.

Hot Target Room	To handle radioactive test targets. Required for preparation of targets and for protection of personnel.
Access to Interior of Target Shielding	Installation of access-way to interior of Target shielding. For access to target enclosure with one roof block removed.
Target Vessel Handling Equipment	Modification of Target handling equipment. For better handling of target vessel. Required to prevent damage of target vessel
5. Modifications and Additions to Drift Tubes and Associated Equipment	
Changes to Drift Tube Cleaning House	Increase floor space in Dt cleaning house. Required to handle cleaning of all DT's. Required for removal of temperary wiring and piping and protection of personnel.

Drift Tube Heating	Heating of drift tubes to facilitate outgassing of shells. Required to reduce bakeout time during operations.
Modify Illumination Housing Periscopes	Provide better means for illuminating interior of vessel. Required to eliminate breakage of vacuum glass ports.
Modify Remaining Drift Tubes	Installation of Modified Drift Tube shells on remaining drift tubes. To cover drift tubes with more satisfactory type of material. Required to permit operation at higher potential gradient without excessive sparking.

Portable Blower - Drier	To dry out drift tube and transmission lines for leak hunting. To reduce time required for vacuum tightness test.

6. **Modifications and Additions to Vacuum System**

Mercury Decontamination	To clean mercury contaminated equipment. Required to reduce mercury hazard to personnel.
Walksways on Mark I Vessel Heads for Magnafluxing	Permanent walkways for vessel heads. To provide safe access to the peripheral sections of the heads to magnaflux critical areas.

	To increase safety and decrease cost of magna-fluxing.
Booster Pump Conversion	Provide treated water and distilled water for all booster pumps. Required to reduce scale in cooling lines.
Vacuum Test Equipment	Provide an Ion gauge storage and test vessel. Required for installation of ion gauges with proper calibration.
Refrigeration Compressor	Refrigeration stand-by compressor. For stand-by operation. Required for reliable operation.
Metal Shield Over Door	Install metal shield under injector platform and over 20' door.

To keep water, dirt, etc., out of vacuum vessel, and to keep liquid nitrogen leaks from dripping on head. Required to help maintain high vacuum, and to avoid cracking vessel head with liquid nitrogen spills.

7. Miscellaneous Capital Equipment

Undetermined capital item such as refrigeration for diffusion pumps, new drift tube magnets, internal cooling coils for diffusion pumps, etc. For research and development of Accelerator. Required to obtain better and more efficient operation and research data.

MARK I ACCELERATOR MODIFICATIONS AND ADDITIONS

COST SUMMARY

Item	Completed to 1/1/53	In Progress FY 1953	New Work FY 1953	New Work FY 1954
Modifications and Additions to Accelerator completed and in progress	$552, 036	$259, 461	$ 0	$ 0
Modifications and additions to Power Supply and Control Equipment	0	0	24, 100	0
Modifications and Additions to Oscillators	0	0	40, 000	0
Modifications and Additions to Target Area	0	0	143, 500	8, 000
Modifications and Additions to Drift Tubes and Associated Equipment	0	0	96, 500	500, 000
Modifications and Additions to Vacuum System	0	0	41, 500	13, 000
Miscellaneous Capital Items such as Refrigeration for Diffusion Pumps, New Drift Tube Magnets, Etc.	0	0	56, 365	181, 319
TOTALS	$552, 036	$259, 461	$401, 965	$702, 319

Budget Category 2-271-001-05
Location Building 57

[redacted]

HIGH POWER OSCILLATOR LABORATORY

A. Description

The facilities are housed in a former airplane hangar utilizing approximately 15,000 square feet of building area. A sub-station, cooling tower and pumping equipment are located immediately outside of the building. A vessel which acts as a high frequency, high Q and high power load capable of handling the output of the largest vacuum tube which can be foreseen in the near future constitutes the oscillator test cavity. This vessel is a resonant cavity 10 feet in diameter and approximately 17 feet high, fabricated of copper clad steel. The vessel is equipped with a cooling system to remove heat and maintain a constant Q over widely changing load conditions, and must be evacuated to prevent sparking. The vacuum system capable of reducing the pressure in the vessel to approximately one billionth of atmosphere consists of three 32-inch mercury diffusion pumps backed by five mechanical vacuum pumps. Liquid nitrogen and freon baffles are installed in the lines between the pumps and the cavity to avoid contamination of the vessel with either mercury or mechanical pump oil. The vessel is surrounded by concrete shielding for protection of operating personnel against high intensity gamma radiation.

Four major power supplies have been installed for the operation and testing of multi-megawatt vacuum tube oscillators. The largest of these power supplies consists of ignitron rectifiers rated at 20,000 volts and 3,000 kilowatts.

The equipment is all remotely controlled from a control console. All systems are completely interlocked to protect against faults, guarantee proper sequence of operation, and insure adequate protection of personnel. Complete instrumentation is available in the control room which indicates the operation of all equipment and provides test information.

B. Utilization

Operation of this facility for adjustment purposes is nearly complete. The equipment can be used to simulate Mark I RF performance and operational procedures. It can also be used to test new developments in oscillators and thereby contribute design information for a production accelerator.

C. Need

The production of RF fields is a fundamental problem in linear accelerator design and equipment for producing, distributing, and controlling RF power represents a large fraction of the accelerator

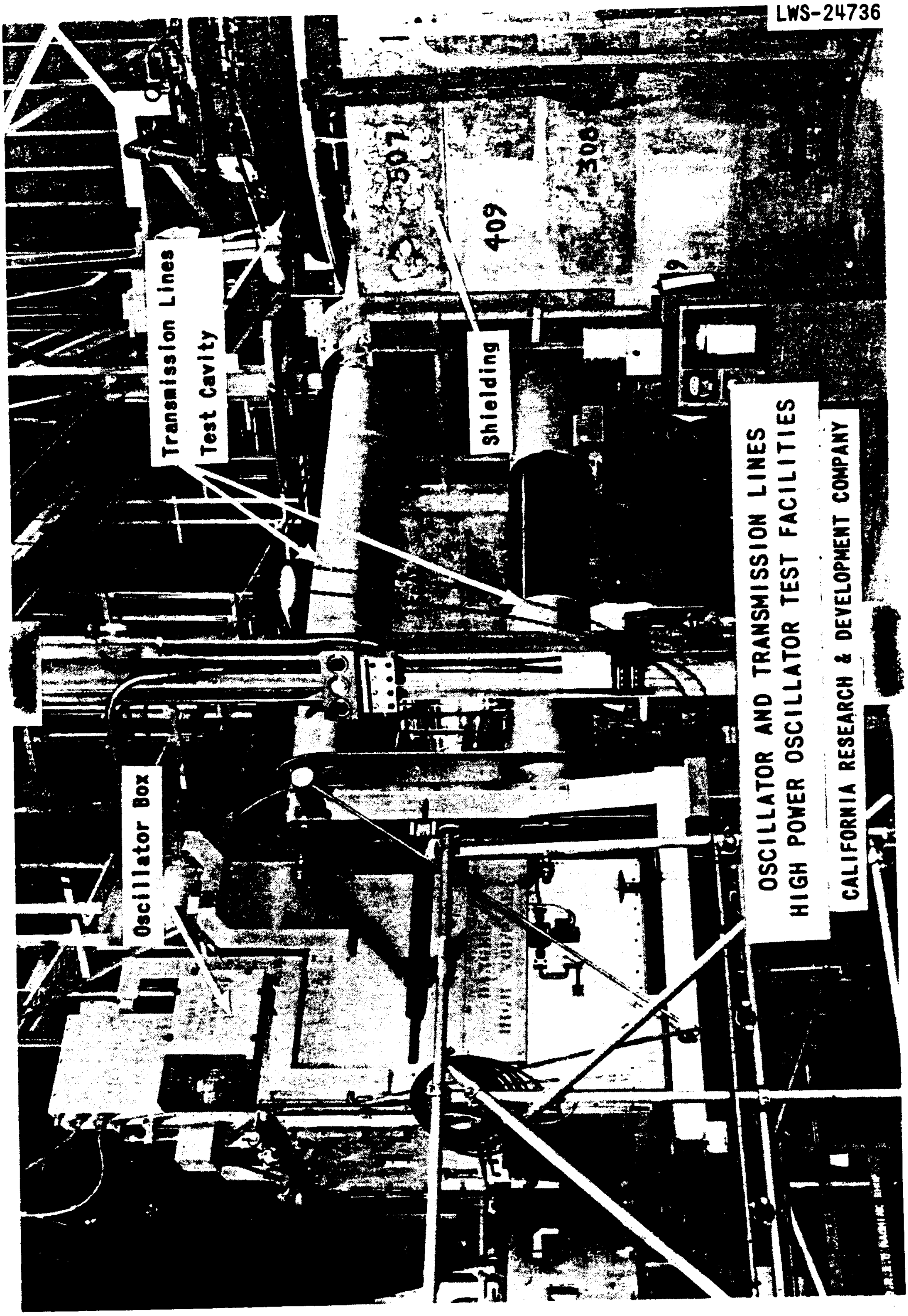
investment cost. Mark I is used for RF development work, but its use for this purpose is limited by inability to make design modifications in the RF system because of expense and interference with operation. A separate test facility is required in which minor design changes can be made readily, deliberate excessive loading of RF equipment produced and the effects studied without endangering a major investment. This test facility can be operated, with minor modification, at the higher frequencies required for the most recent conceptual design of less expensive accelerators.

HIGH POWER OSCILLATOR LABORATORY

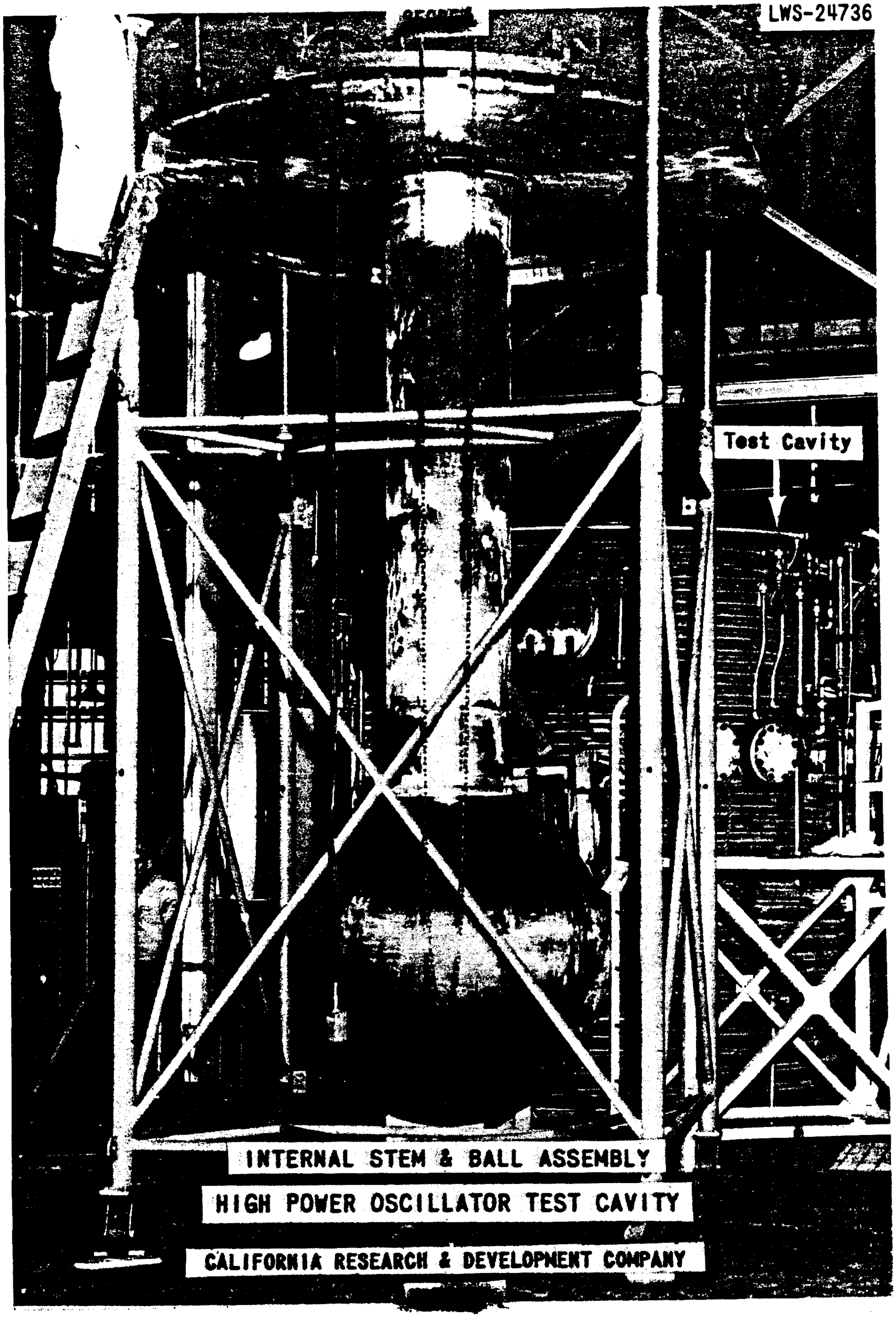
COST SUMMARY

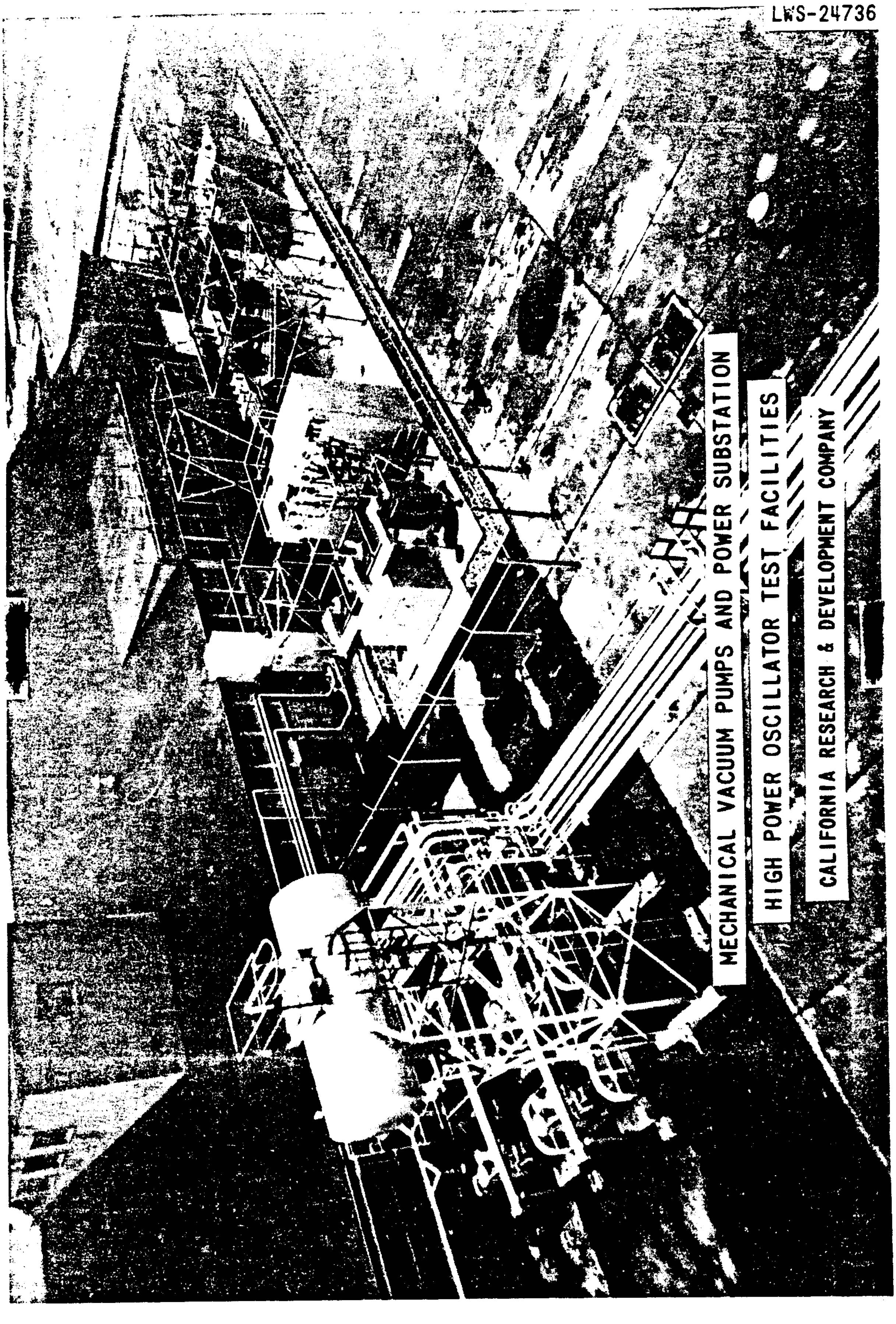
Item & Location	Complete to 1/1/53	In Progress FY 1953	New Work FY 1953	New Work FY 1954
Building Alterations and Shielding Building 12	$148,000	$ 0	$ 0	$ 0
Power Supplies, Oscillator, Distribution System Building 12	810,000	0	0	0
Instrumentation Building 12	184,000	0	0	0
Vacuum, Utility and Nitrogen Piping Building 12	141,000	20,000	0	0
Test Load Cavity, Tanks and Transmission Lines Building 12	378,000	0	0	0
Heat Exchangers, Pumps, Cooling Tower Building 12	147,000	0	0	0
Miscellaneous Equipment Building 12	40,809	42,469	0	25,000
TOTAL	$1,848,809	$62,469	$ 0	$25,000

Budget Category 2-271-1001-08



OSCILLATOR AND TRANSMISSION LINES
HIGH POWER OSCILLATOR TEST FACILITIES
CALIFORNIA RESEARCH & DEVELOPMENT COMPANY


Test Cavity
INTERNAL STEM & BALL ASSEMBLY
HIGH POWER OSCILLATOR TEST CAVITY
CALIFORNIA RESEARCH & DEVELOPMENT COMPANY


MECHANICAL VACUUM PUMPS AND POWER SUBSTATION
HIGH POWER OSCILLATOR TEST FACILITIES
CALIFORNIA RESEARCH & DEVELOPMENT COMPANY

ION SOURCE DEVELOPMENT LABORATORY

A. Description

The original facilities for development of high energy ion source equipment suitable for Mark I injection were first constructed at the University of California Radiation Laboratory and later moved to Livermore and installed in an existing building when the California Research and Development Company assumed responsibility for the developmental work. The main power supply equipment was installed in an adjacent steel-shielded building constructed for this purpose. The equipment consists of an ion injector with associated power equipment including transformers, voltage regulators, rectifiers, switch gear, control panels and control equipment. In addition there are mercury diffusion pumps, mechanical vacuum pumps, an air compressor and utility lines for cooling water, chilled water and air.

The continuing program includes modifications to the original equipment to realize higher injection energies than those previously obtained. These changes include the addition of a high frequency section and provision for improved beam focusing.

A sketch of this laboratory is attached.

B. Utilization

Work to date in the Ion Source Development Laboratory has resulted in injector current outputs of over 2-1/2 amperes of protons or deuterons. Operation at 100 KV has greatly increased the stability and reliability of the ion source and has lead to the current modifications where operation at several hundred KV is anticipated.

C. Need

The development of higher injection energies will improve the operation of Mark I since it will permit the elimination of the troublesome small gap required between the injector end of the accelerator resonant cavity and the first drift tube. This small gap has been the major region of spark damage in the Mark I Accelerator.

In addition, facility modifications will permit the study of higher energy injection along with Brookhaven-type focusing of accelerated proton or deuteron beams. A full knowledge of the techniques of Brookhaven-type focusing is an essential step in determining the feasibility of less expensive small diameter production type linear accelerators.

ION SOURCE DEVELOPMENT

COST SUMMARY

Item & Location	Completed to 1/1/53	In Progress FY 1953	New Work FY 1953	New Work FY 1954
Injector Test Facility Building 12	$155,126	$ 0	$ 0	$25,000
Auxiliary Vacuum System Ion Source Building 12	4,476	0	0	0
Freon Compressor For Test Facility Building 12	1,181	319	0	0
TOTALS	$160,783	$ 319	$ 0	$25,000

Budget Category 2-271-1001-09

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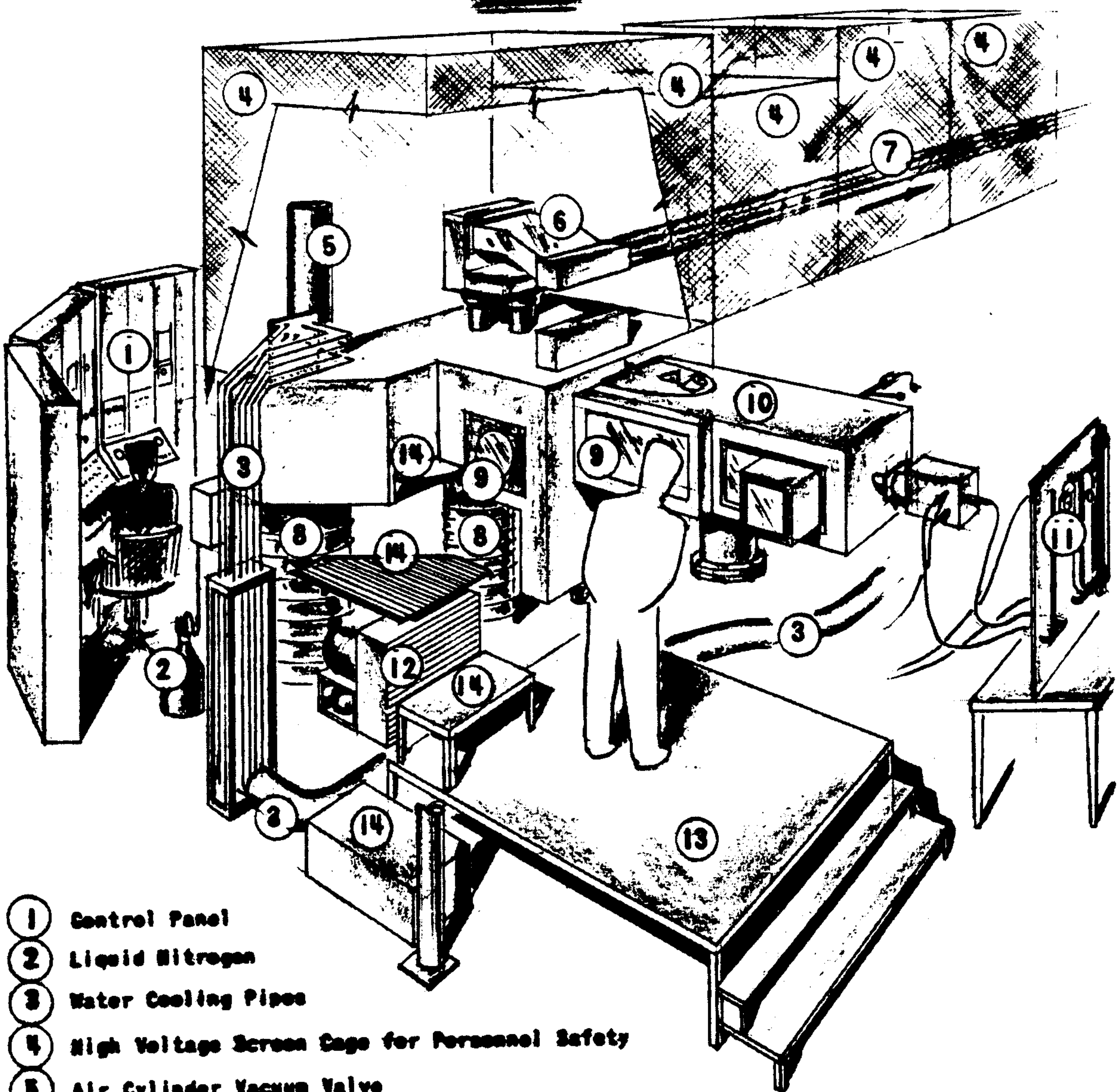

1. Control Panel
2. Liquid Nitrogen
3. Water Cooling Pipes
4. High Voltage Screen Cage for Personnel Safety
5. Air Cylinder Vacuum Valve
6. High Voltage Connection
7. Bus Duct to High Voltage Supply
8. 20" Diffusion Pump System
9. Observation Window
10. Collector Assembly
11. Calorometric Beam Measuring Apparatus
12. Refrigerator Compressor
13. Observation Platform
14. Steps

INJECTOR DEVELOPMENT LABORATORY

CALIFORNIA RESEARCH & DEVELOPMENT COMPANY

[redacted]

MISCELLANEOUS LINEAR ACCELERATOR RESEARCH FACILITIES

A. Description

These laboratory research facilities for the linear accelerator were first developed at the University of California Radiation Laboratory and later moved to Livermore. Included were a 1/10 scale RF model of the Mark I Accelerator resonant cavity, an electron model, and a number of small scale models as well as some auxiliary equipment.

Additional models and alterations to existing models as required for further study are being acquired, or will be acquired. These include a new RF model, phasing cavities, a screen room for RF work, an electronic shop, and other facilties. Most of the items in this category are expendable, but the establishment of an adequate laboratory in Building 29 (a former warehouse) is essential to this work. Capitalizable facilities include the improved Mark I RF scale model, screen room, equipment for sparking and strong focusing studies, and other miscellaneous small facilities.

B. Utilization

The original equipment was first utilized to establish the design parameters and equipment geometries necessary to obtain the desired

electric field configuration in Mark I. Special models and control instruments were also used and continue to be necessary for diagnostic studies of the accelerator. Additional models and alterations to existing models will be used to verify the feasibility and to determine the design parameters of improved type accelerators.

C. Need

New models and altered existing models as well as adequate laboratory space are required to establish and verify the design parameters of proposed new accelerators. They are needed also for verifying the validity of alterations to Mark I; for example, modifications to drift tubes can be made with much less time and expense by first checking the designs on the 1/10 scale RF model of the cavity.

MISCELLANEOUS ACCELERATOR RESEARCH FACILITIES

COST SUMMARY

Item & Location	Completed to 1/1/53	In Progress FY 1953	New Work FY 1953	New Work FY 1954
Vacuum & Ion Pump Research Programs Building 12	$ 73,852	$14,707	$ 0	$ 0
Mark I Model Construction Building 28	9,908	6,555	0	0
Accelerator Development Equipment Building 12	68,643	0	0	0
Phasing Cavity Building 12	0	0	4,000	6,000
Sparking Study Equipment Building 12	0	0	5,000	0
Glow Ball Building 12	0	0	5,000	0
Miscellaneous Equipment Building 12	0	0	23,263	13,000
Preliminary Engineering	3,664	0	0	0
TOTALS	$156,067	$21,262	$41,563	$19,000

Budget Category 2-271-1001-09

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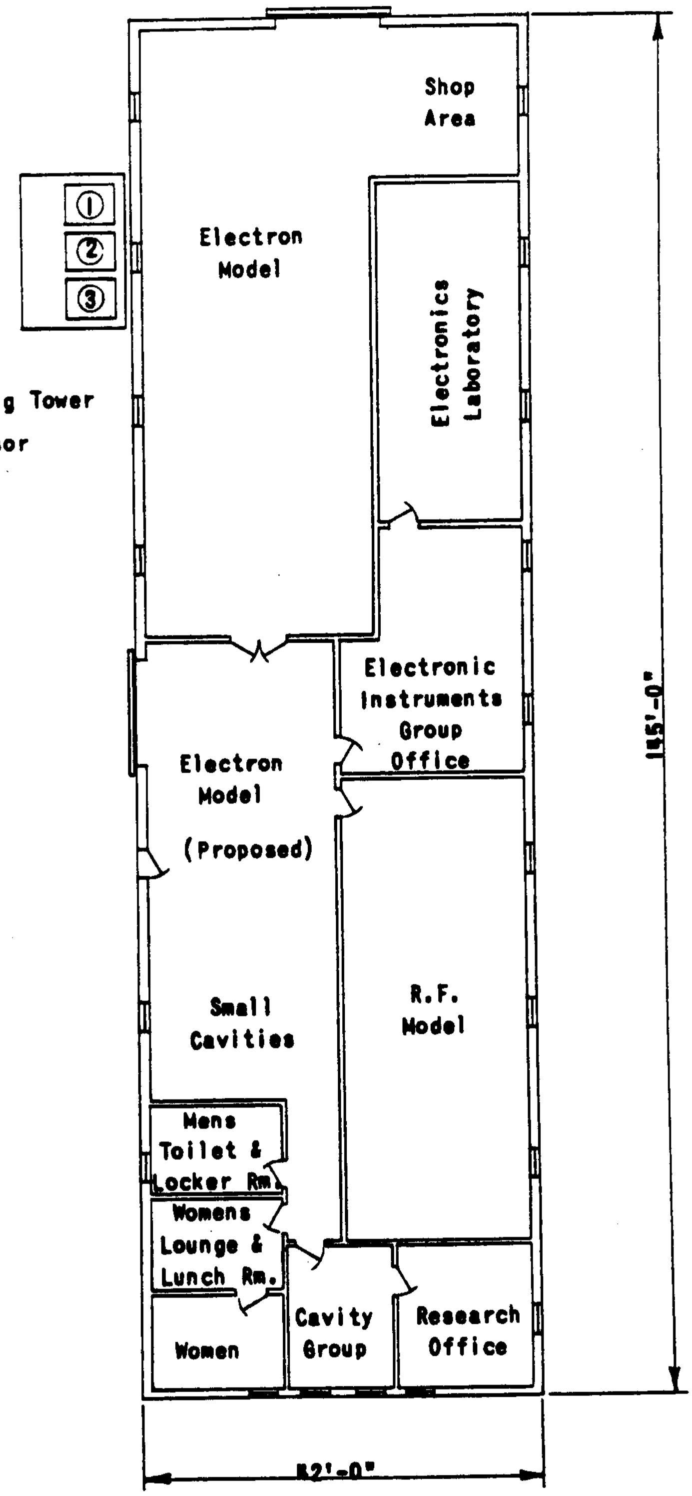

1. Water Cooling Tower
2. Air Compressor
3. Kinney Pump

DEVELOPMENT DIVISION LABORATORY

CALIFORNIA RESEARCH & DEVELOPMENT COMPANY

[redacted]

TARGET MATERIAL AND PROCESSING LABORATORY

A. Description

Facilities for these MTA programs consist of two converted existing buildings at the Livermore Research Laboratory plus additional space in another existing building.

Temporary Process Research Laboratory

This facility of 4300 square feet of floor area is located in a concrete building as shown on attached drawing. The area associated with process research includes a chemical laboratory, a counting room, and rooms fitted out for offices, balances, and health physics.

The laboratory is equipped with glove boxes, chemical forced-draft hoods and research type laboratory equipment and counting devices.

No additional capital requirements are indicated during FY 1953 or FY 1954.

Process Development Laboratory

The main facility concerned with target materials and processing is a renovated building of approximately 25,000

square feet which is now being prepared for occupancy. The building is divided functionally into a radive laboratory area of 12,000 square feet and a non-radive area of 9,500 square feet. The ventilation and service areas occupy an additional 3,500 square feet.

Special features of the radive section of the building include six 8 foot x 8 foot concrete cells with walls two feet thick and varying in depth from 10 to 30 feet; special intake and exhaust ventilation systems employing hoods and filters; and segregation of radioactive wastes from sanitary wastes. The laboratories in the non-radive area of the building are equipped for chemical and metallurgical research including such facilities as tensile and fatigue testing machines, X-ray diffusion, metallograph, an electron microscope and specimen preparation equipment.

Research equipment located in the building may be described as the minimum required for basic research in chemistry, metallurgy and engineering in a project of the scope and magnitude of the MTA program.

An example of special equipment installed in the laboratory is a 500 KVA thermal cycler which is a unique device

designed to provide a pulsating heat load in target specimens. Drawings of the thermal cycler are attached.

Proposed modifications to the building include alteration of two laboratories for radiochemical use, additions and improvements to cell area equipment and added electrical power distribution within the building. Increased storage capacity for used equipment and operating supplies will also be needed.

Additional research equipment will be needed to complement existing items or to increase the capacity of existing equipment. Such metallurgical and metal equipment as a vacuum melt furnace, creep test and impact hardness machines, dynamic corrosion, Magnaflux and Zyglo testers fall into this category. Requirements in the chemistry group for equipment are a pulse height analyzer, large combustion train, lead-shielded glove boxes and recording control equipment.

Additional instrumentation and modifications to the resistance thermal cycler will also be needed.

Other Target and Process Facilities

Additional space will be required for work on the metallurgy of uranium and other materials. A minimum of 3,000